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ORIGINAL ARTICLE
ORİJİNAL ARAŞTIRMA

Investigation of the Effect of Spinal Stabilization and Fusion on Intervertebral Disc Structures Using Density

Spinal Stabilizasyon ve Füzyonun İntervertebral Disk Yapıları Üzerine Etkisinin Dansite Kullanılarak İncelenmesi

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ABSTRACT

Introduction: The effects of stabilization and fusion on the intervertebral discs in the fusion region of the spine and adjacent segments have been rarely studied in the literature. In the literature, few animal experiments and biomechanical studies have shown that the disc structure undergoes some metabolic changes and degeneration develops after posterior fusion. The response of cells in the intervertebral discs to inmobilization or overmobilization was thought to occur mostly due to the effect of mechanical forces on disc nutrition. The aim of our study; To determine the density (IVDD) changes in the intervertebral discs in the early and late postoperative period in patients who underwent posterior spinal fusion and to contribute to the few studies in the literature.

Material and Method: The records of patients who were diagnosed with lumbar spondylosis and narrow canal in our clinic between 2015-2021 were reviewed retrospectively. Postoperative early (day 1) and postoperative late (4-6 months) lumbar computed tomography (CT) scans of patients who underwent L2-3-4-5 transpedicular screw and L2-3-4 lumbar laminectomy were examined. Density measurements were made in the fusion region and adjacent segment. The results were evaluated statistically.

Results: The difference between early and late IVDD values performed at the same disc level in all disc levels was statistically significant ($p<0.001$). In repeated measurements, postoperative early postoperative IVDD values of disc levels were statistically insignificant ($p>0.05$), while late-term IVDD values were significant ($p<0.001$).

Conclusion: In patients who underwent rigid fusion of the lumbar with the posterior instrumentation technique, significant density differences develop in the disc segments in the fusion region and less frequently in the adjacent disc segments in the fusion region within a period of 4-6 months. This may support that the rigid fusion technique causes a degenerative process in disc structures.

Keywords: Spinal stabilization, spinal fusion, intervertebral disc degeneration

ÖZ

Giriş: Stabilizasyon ve füzyonun omurganın füzyon bölgesinde ve de komşu segmentlerdeki intervertebral diskler üzerine etkisi literatürede nadiren incelenmiştir. Literatüterde az sayıda yapılmış hayvan deneylerinde ve biyomekanik çalışmalarda posterior füzyon sonrasında disk yapısının metabolik bazı değişikliklere uğradığı ve dejenerasyon geliştiği gösterilmiştir. İntervertebral disklerdeki hücrelerin inmobilizasyona veya aşırı mobilizasyona verdiği tepki daha çok mekanik güçlerin disk beslenmesi üzerine etkisi nedeniyle oluştuğu düşünülmüştür. Çalışmamızın amacı; posterior spinal füzyon yaptığımız hastalarda postoperatif erken ve geç dönemde intervertebral disklerdeki dansite (İVDD) değişikliklerini belirlemek ve literatüredeki az sayıda çalışmaya katkı sunmaktır.

Gereç ve Yöntem: Kliniğimizde 2015-2021 yılları arasında lomber spondiloz ve dar kanal tanısı almış hastaların kayıtları retrospektif olarak incelendi. L2-3-4-5 transpediküler vida ve L2-3-4 lomber laminektomi uygulanmış hastaların postoperatif erken dönem (1. Gün) ve posoperatif geç dönem (4-6 ay) lomber bilgisayarlı tomografileri (BT) incelendi. Füzyon bölgesinde ve komşu segmentte dansite ölçümleri yapıldı. Sonuçlar istatistiksel olarak değerlendirildi.

Bulgular: Tüm disk seviyelerinde aynı disk seviyesinden yapılan erken ve geç dönem İVDD değerleri arasındaki fark istatiksel olarak anlamlı idi ($p<0,001$). Tekrarlı ölçümlerde disk seviyelerinin postoperative erken dönem İVDD değerleri istatiksel olarak anlamsız ($p>0,05$), geç dönem İVDD değerleri ise anlamlı ($p<0,001$) idi.

Sonuç: Posterior enstrümantasyon tekniği ile lomber rijit füzyon yapılan hastalarda postoperative 4-6 ay gibi bir sürede füzyon bölgesindeki disk segmentlerinde belirgin, üstteki komşu disk segmentinde ise daha az oranda dansite farklılıkları gelişmektedir. Bu durum rijit füzyon tekniğinin disk yapılarında dejeneratif bir sürece neden olduğunu destekleyebilir.

Anahtar Kelimeler: Spinal stabilizasyon, spinal füzyon, intervertebral disk dejenerasyonu

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INTRODUCTION

Lumbar intervertebral disc degeneration; It is one of the causes of chronic low back pain, which is very common in society and causes severe movement restriction (1). Disc degeneration also increases with advancing age (2). If lumbar disc degeneration continues for a long time; lumbar disc hernias, facet joint hypertrophies, posterior longitudinal ligament and ligamentum flavum hypertrophy/calcifications, narrowing of the spinal canal and neural foramen, anterior or posterior listesis, etc. degenerative diseases may develop (3,4). Analgegic and anti-inflammatory drugs are used in medical treatment. Restriction of movement with physiotherapy and corset may also be partially beneficial. Patients who do not benefit from these treatments are treated with surgery (4).

Posterior lumbar spinal instrumentation; It is often performed to reorganize the sagittal and/or coronal balance caused by degeneration, to eliminate instability, and to strengthen the spinal structure as a result of decompression and fusion in the spinal canal and neural tissues (5). There are rigid and dynamic fusion options. In both, it is aimed to relieve pain due to degeneration (6). This bona fide surgical procedure causes changes in the biomechanics of the spine and the biological characteristics of the associated soft tissues (7,8,9).

The effect of spinal instrumentation and fusion on intervertebral discs, both at the fusion site and adjacent segments, is a rarely explored issue. In the literature, few animal experiments and biomechanical studies have shown that the disc structure undergoes some metabolic changes and degeneration develops after posterior fusion. The response of the cells in the intervertebral discs to immobilization was thought to occur mostly due to the effect of mechanical forces on disc nutrition (5,7,10,11,12). The aim of our study; To determine the density (IVDD) changes in the intervertebral discs in the early and late postoperative period in patients who underwent posterior spinal fusion and to contribute to the literature.

MATERIAL AND METHOD

The records of patients who were diagnosed with lumbar spondylosis and narrow canal in our clinic between 2015 and 2021 were reviewed retrospectively. L2-3-4-5 transpedicular screw and L2-3-4 lumbar laminectomy were applied to all patients. Postoperative early period (day 1) and postoperative late period (4-6 months) CT scans of the patients were examined. Density measurements were made using the SECTRA field density measurement program at the distances of L4-5 L3-4 L2-3 in the fusion region and L1-2 intervertebral disc distances as the adjacent segment. Hounsfield Unit (HU) was used as the density unit. Continuous variables were defined as mean ± standard deviation. The results were statistically evaluated with the SPSS 25.0 (IBM, Armonk, NY, USA) program. Paired samples t test was used for the significance of the difference between the early and late postoperative density values of a disc level, and analysis of variance was used for repeated measurements. Statistical significance level was accepted as $p<0.05$.

RESULTS

Nine patients who underwent rigid fusion to L2-3-4-5 vertebrae with posterior transpedicular instrumentation technique to L2-3, L3-4 and L4-5 intervertebral disc segments in our clinic between 2015-2021 were included in the study. Six of the patients were female and 3 were male. The mean age was 58.89±3.82 (54-65). The lowest IVDD and disc level measured in the early postoperative period; It was L2-3 level with 65.72 in female patients and L3-4 disc level with 68.88 in male. The highest IVDD and disc levels measured in the early postoperative period were 127, L3-4 and 105, L2-3 levels in women and men, respectively. Likewise, the highest and lowest IVDD and disc levels measured in the late postoperative period were 87.24, L3-4 in female and male, respectively; 36.44, L3-4; 85.44, L2-3; 39.76 was the L2-3 disc level (**Table 1**).

Table 1. Measurement of the disc spaces with Hounsfield unit

Patient Number	Age	Sex	Density of L4-5 Disc Space		Density of L3-4 Disc Space		Density L2-3 Disc Space		Density L1-2 Disc Space	
			Postoperative Early	Postoperative Late	Postoperative Early	Postoperative Late	Postoperative Early	Postoperative Late	Postoperative Early	Postoperative Late
1	56	F	102±30.65	72.99±111	127±34.16	80.46±117	91.78±43.29	70.55±97.79	91.88±76.35	82.66±98.76
2	64	F	88.31±44.52	47.97±51.71	81±64.28	36.44±63	65.72±43.23	44.32±26.53	76.88±93.51	73.73±86
3	58	F	87.93±145	50.14±83.35	118±149	87.24±72.77	117±140	74.37±81.35	82.83±179	69.75±77.21
4	59	M	90.05±43.03	72.11±83.07	86.55±43.46	61.27±72.61	105±51.28	71.55±94.11	89.12±60.77	85.44±70.12
5	54	F	70.12±98.32	54.17±69.79	86.24±113	62.43±101	88.94±118	64.59±91.93	74.77±100	71.46±83.02
6	65	M	76.72±53.7	43.5±19.58	80.94±37.47	41.14±20.45	71.94±64	39.76±18.18	73.29±56.66	65.7±83.91
7	58	M	81.72±65.64	53.12±70.71	68.88±59.23	43.17±51.69	73.41±71.2	45.39±60.1	82.31±88.55	76.23±37.12
8	55	F	95.19±11.47	70.55±30.91	102±17.74	80.22±28.71	99.86±17.26	81.86±24.06	99±25	84.25±24.31
9	61	F	84.54±54.06	55.43±77.6	88.91±57.54	60.73±27.17	91.47±55.82	64.24±77.10	76.74±46.65	71.9±65.49

The highest and lowest IVDD values measured in the early postoperative period according to disc levels; It was 99 and 73.29 in L1-2, 117 and 65.72 in L2-3, 127 and 68.88 in L3-4, 102 and 70.12 in L4-5. Likewise, the highest and lowest IVDD values measured in the late postoperative period according to disc levels; 85.44 and 65.70 in L1-2, 81.86 and 39.76 in L2-3, 87.24 and 36.44 in L3-4, 72.99 and 43 in L4-5 was 50. Postoperative early and late IVDD mean values with standard deviation; 82.98±8.74 and 75.68±6.97 at L1-2, 89.46±16.76 and 61.85±15.03 at L2-3, 93.28 at L3-4 It was ±18.83 and 61.46±18.55, and 86.29±9.51 and 57.78±11.17 in L4-5. The difference between early and late IVDD values performed at the same disc level in all disc levels was statistically significant ($p<0.001$) (**Table 2**, **Figure 1**). In repeated measurements, postoperative early postoperative IVDD values of disc levels were statistically insignificant ($p>0.05$), while late-term IVDD values were significant ($p<0.001$) (**Table 3**).

Table 2: General distribution of variables

Variables	Meant±SS	Min	Max
Age	58,89±3,82	54,00	65,00
L4-5 Disc Space Postoperative Early	86,29±9,51	70,12	102,00
L4-5 Disc Space Postoperative Late	57,78±11,17	43,50	72,99
p	<0,001		
L3-4 Disc Space Postoperative Early	93,28±18,83	68,88	127,00
L3-4 Disc Space Postoperative Late	61,46±18,55	36,44	87,24
p	<0,001		
L2-3 Disc Space Postoperative Early	89,46±16,76	65,72	117,00
L2-3 Disc Space Postoperative Late	61,85±15,03	39,76	81,86
p	<0,001		
L1-2 Disc Space Postoperative Early	82,98±8,74	73,29	99,00
L1-2 Disc Space Postoperative Late	75,68±6,97	65,70	85,44
p	0,001		

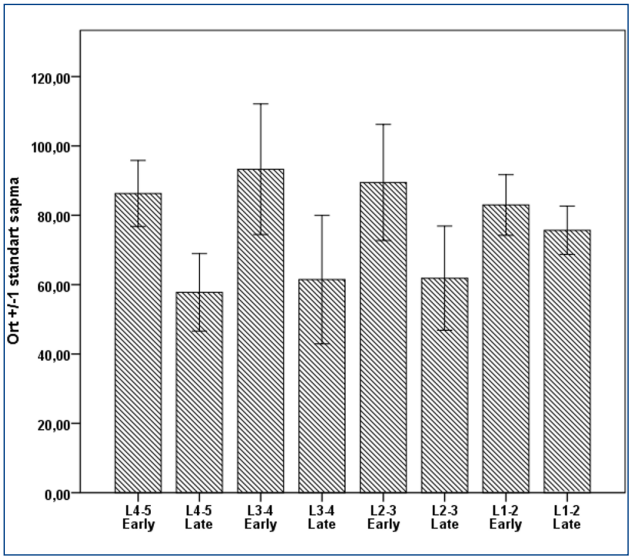

Figure 1: Standard deviation bar graph for measurements

Table 3: Relationship between repeated measures Analysis of variance was used for repeated measures. (ab): A common letter as a colon indicates statistical insignificance.

	Mean±SS
L4-5 Disc Space Postoperative Early	86,29±9,51
L3-4 Disc Space Postoperative Early	93,28±18,83
L2-3 Disc Space Postoperative Early	89,46±16,76
L1-2 Disc Space Postoperative Early	82,98±8,74
p	0,336
L4-5 Disc Space Postoperative Late	57,78±11,17 (a)
L3-4 Disc Space Postoperative Late	61,46±18,55 (ab)
L2-3 Disc Space Postoperative Late	61,85±15,03 (ab)
L1-2 Disc Space Postoperative Late	75,68±6,97 (b)
p	0,001

DISCUSSION

As we mentioned before, there is no study in the literature investigating the effect of posterior lumbar instrumentation on intervertebral discs, except for a small amount of animal experiments and biomechanical studies. In these studies, histochemical and metabolic changes of the interverbral disc were examined (5,7,8,9,10,11,12). We believe that our study, which presents the density changes by measuring the early and late IVDD of patients with whom we had posterior fusion, will contribute significantly to the literature. In addition, we included the density values of the L1-2 disc level in our study, since the adjacent disc segment just above the fusion region is also very affected by fusion stress (6).

The average densities of non-degenerated lumbar intervertebral discs on tomography are above 90 (13) and decrease below 50 in patients who underwent discectomy (on the 3rd-6th days postoperatively) (14). Since we did not perform discectomy on the patients in our study, the early measurements (postoperative day 1) actually reflect the preoperative IVDD values. Physiological lumbar disc degeneration due to spinal aging begins in the 5th decade (15). In our study, the mean age of our patients was 58.89 years and the mean early period IVDD of L1-2, L2-3, L3-4, L4-5 disc distances were 82.98 , 89.46 , 93.28, 86.29, respectively. shows that the degeneration started partially preoperatively. In addition, IVDD differences between intervertebral disc levels are not statistically significant.

Holm S et al. (7) proved with animal experiments that there is a decrease in IVDD in the immobilized segments and adjacent segments after posterior spinal fusion. In this study, an average of 30% decrease in IVDD was reported at the 5th month postoperatively, 50% in the 8th month, and 10% in the adjacent segment in the fusion segments. In our study, there was a 33% decrease in IVDD at the level of the fused segments L4-

5, 34% at the level of L3-4, 31% at the level of L2-3, and 9% at the adjacent segment L1-2 in the postoperative 4-6th months. Postoperative IVDD mean values on the 1st day and 4-6th months; 82.98 and 75.68 in L1-2, 89.46 and 61.85 in L2-3, 93.28 and 61.46 in L3-4, 86.29 and 57 in L4-5 was .78. The decrease in IVDD at all disc levels was statistically significant.

In accordance with the literature, we also; We believe that the degeneration of the lumbar intervertebral discs in the region where the fusion was performed with the posterior instrumentation method and the disc in the adjacent segment are caused by the restriction of flexion-extension movements and the mechanical forces on the spine in the vertical plane towards gravity cause structural and histochemical changes in the disc content (7).

There are some reasons why we used CT for IVDD measurements in our study. In our clinic, patients undergoing posterior instrumentation routinely undergo lumbar CT on the 1st postoperative day in order to evaluate transpedicular screw placements and laminectomy areas. In addition, during the control examinations of the patients, screw malposition, screw loosening, screw or rod breakage, screw or rod removal, etc. CT examination is also performed for complications caused by instrumentation materials. These CTs are archived in the physical or digital files of our patients. IT has been preferred because it is easy to reach and allows working on it thanks to the advancing computer technology.

The most important limitation of our study; the absence of an unoperated control group at the same mean age. The reasons for this situation; Health and legal concerns arising from the radiation inclusion of CT, the difficulty in daily practice of having healthy individuals undergo CT at least twice within 4-6 months, and the retrospective nature of our study. If we had a control group, it would be possible to compare the normal course of the lumbar intervertebral discs with the response of the discs in the fused region to fusion. Another limitation of ours; Our study was conducted on patients who underwent posterior lumbar rigid fusion, and our patients who underwent dynamic fusion were not included. The reason for this is that the dynamic fusion technique is applied only in patients who underwent short segment fusion in our clinic. However, since there is no study similar to our study in the literature sources we can reach, we still think that our results may be pioneering for academics.

CONCLUSION

In patients undergoing rigid lumbar fusion with the posterior instrumentation technique, significant density changes develop in the disc segments in the fusion region, and less frequently in the adjacent disc segment, within 4-6 months postoperatively. This result may support the development of a degenerative process in disc structures. This may lead to revision of the stabilization and fusion technique. We think that studies with more patients and longer follow-up periods are needed.

ETHICAL DECLARATIONS

Ethics Committee Approval: The study was planned retrospectively and the data were obtained digitally, ethics committee approval is not required.

Informed Consent: Because the study was designed retrospectively, no written informed consent form was obtained from patients.

Referee Evaluation Process: Externally peer-reviewed.

Conflict of Interest Statement: The authors have no conflicts of interest to declare.

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